Automatic Runway Groove Identification and Evaluation

Jeffrey L. Rapol, Civil Engineer

Federal Aviation Administration

Airport Engineering Division, AAS-100

800 Independence Ave, SW Room 621V

Washington, DC 20591

Phone: (202) 267-7474; Fax: (202) 267-3688

jeffrey.rapol@faa.gov

Qiang Wang, Ph.D.

SRA International Inc.

1201 New Road, Suite #242

Linwood, NJ 08221, U.S.A.

Phone: (609) 601-6800; FAX (609) 601-6801

qiang_wang@sra.com

# Outline of Presentation

❑   Introduction to Runway Grooves

❑   Groove Measurement and Identification System

❑   Groove Identification Program – *ProGroove*

        ---   Procedures

        ---   Techniques

        ---   Functions

❑   Verification of *ProGroove* Program

Introduction to Runway Grooves

What is Tire Hydroplaning?

When aircraft tires or highway vehicle tires roll over water covered or flooded pavements, water may penetrate between the tire and the pavement. This penetration results in the formation of water pressure which raises a portion of the tire off the pavement.

This pressure increases as the speed of the vehicle increases, supporting more and more of the tire, until, at a critical speed termed the hydroplaning speed, the tire is supported only by the water and loses all contact with the pavement.
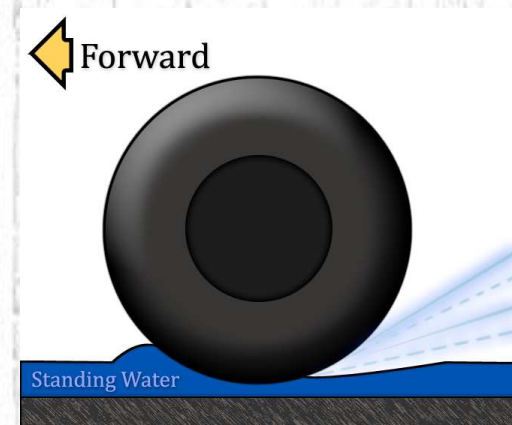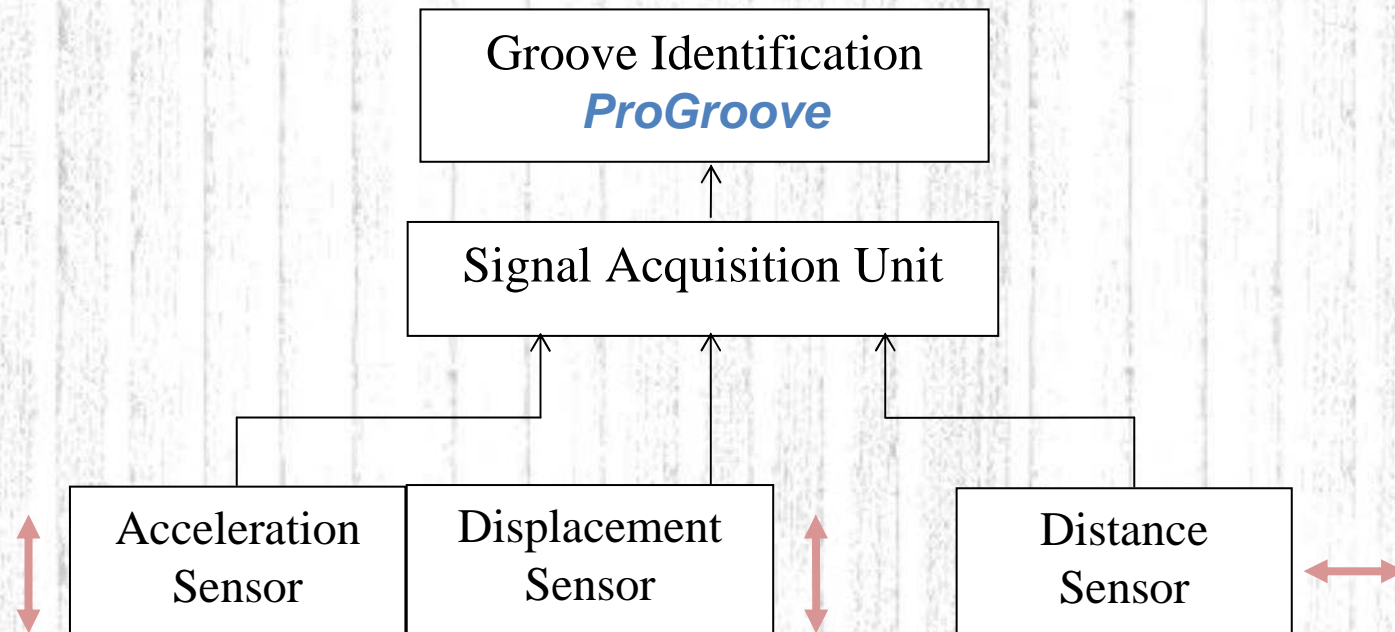
Introduction to Runway Grooves

Cutting or forming grooves in existing or new pavement, which would allow rain water to escape from beneath tires of landing aircraft, is a proven and effective technique for providing skid-resistance and prevention of hydroplaning during wet weather.
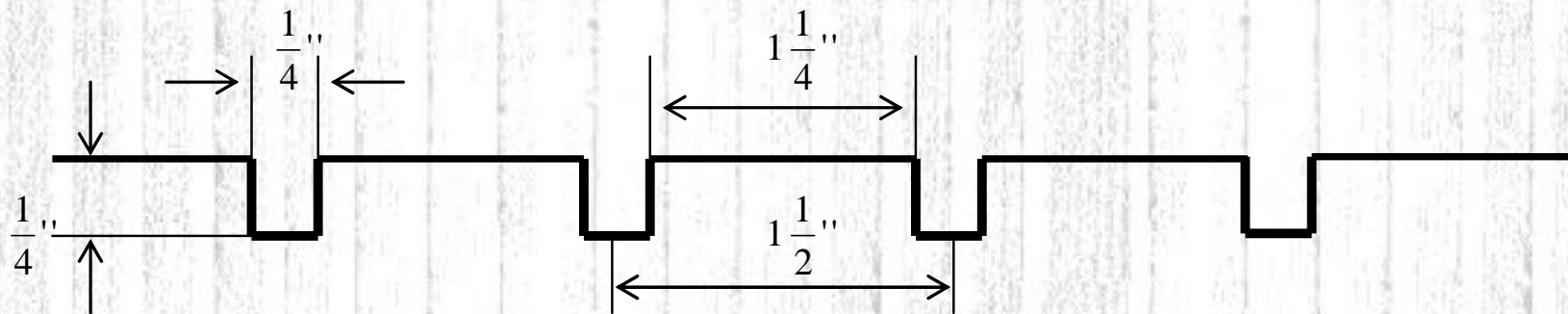
The FAA standard groove configuration is 1/4 inch (±1/16 inch) in depth by 1/4 inch (+1/16 inch, -0 inch) in width by 1 1/2 inch (- 1/8 inch, + 0 inch) center to center spacing.-- *FAA: AC 150/5320-12C*

# Groove Measurement and Identification System

Using a laser displacement sensor, the rapid measurement of surface elevation profiles can be achieved to sufficient accuracy and at fine enough sample spacing to define the characteristics of transverse grooves on airport runways.

```
          ┌──────────────────────────┐
          │  Groove Identification   │
          │       ProGroove          │
          └──────────────────────────┘
                      ↑
          ┌──────────────────────────┐
          │  Signal Acquisition Unit │
          └──────────────────────────┘
             ↑        ↑        ↑
   ┌──────────────┬──────────────┐      ┌──────────────┐
   │ Acceleration │ Displacement │      │   Distance   │
   │    Sensor    │    Sensor    │      │    Sensor    │
   └──────────────┴──────────────┘      └──────────────┘
   ↕                        ↕                         ↔
```

Grooves on Airport Runway

Groove Identification Program

The computer program, *ProGroove*, was developed which automatically identifies grooves in an elevation profile and computes the dimensions of the grooves.
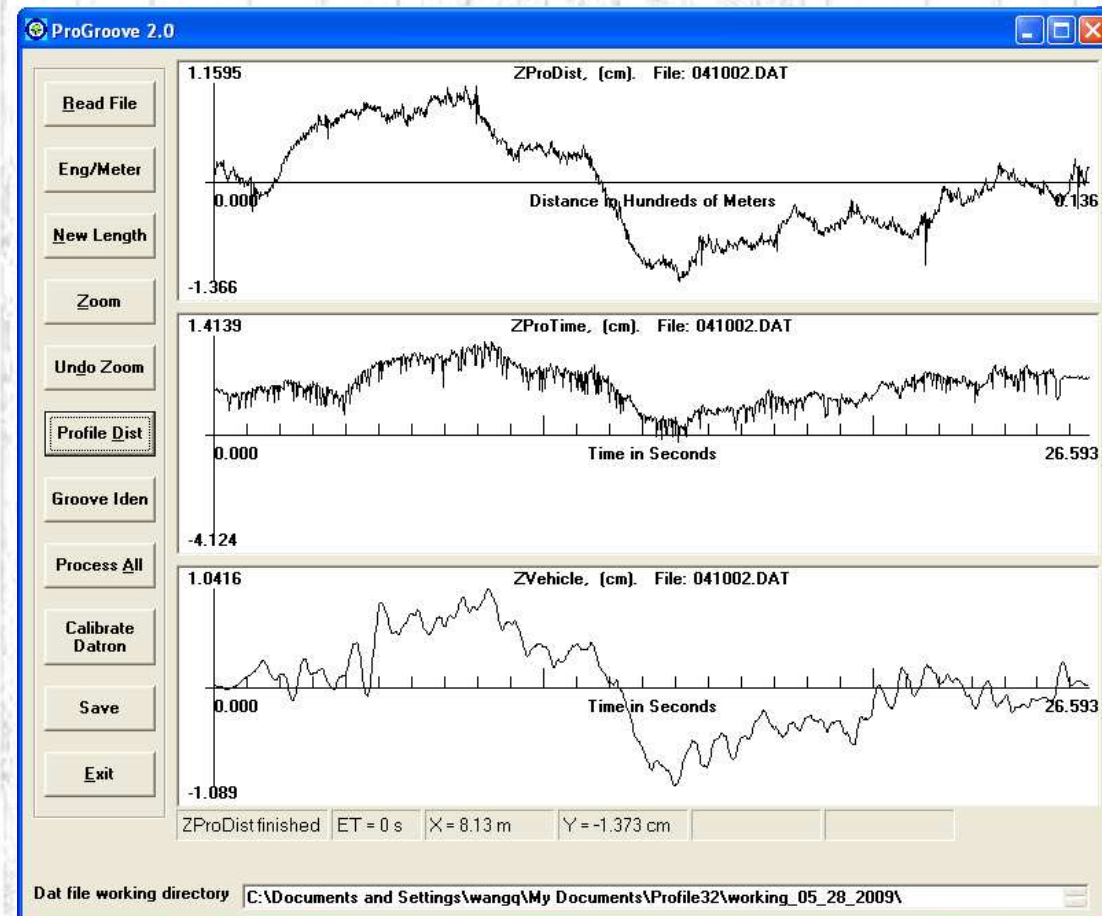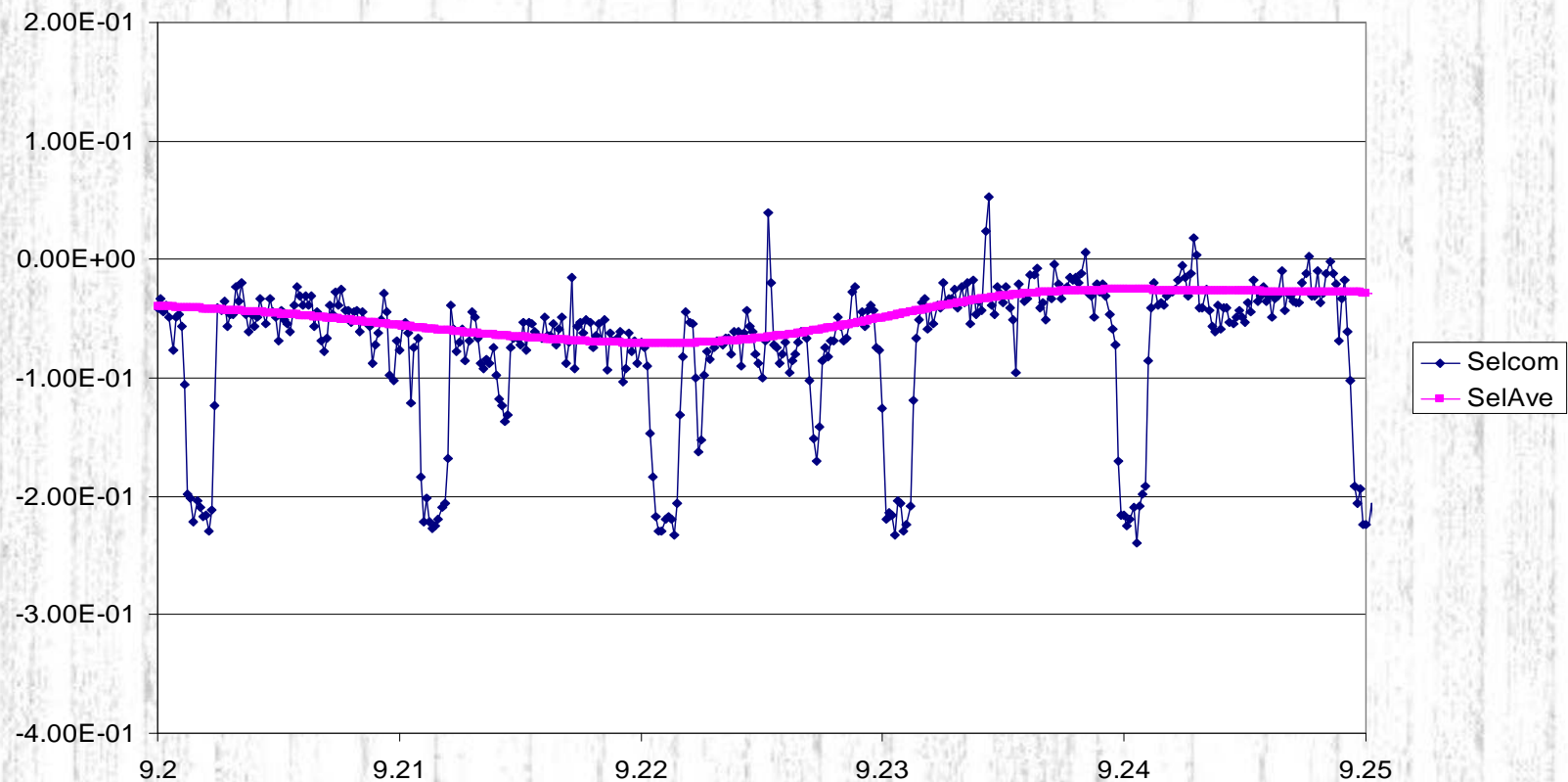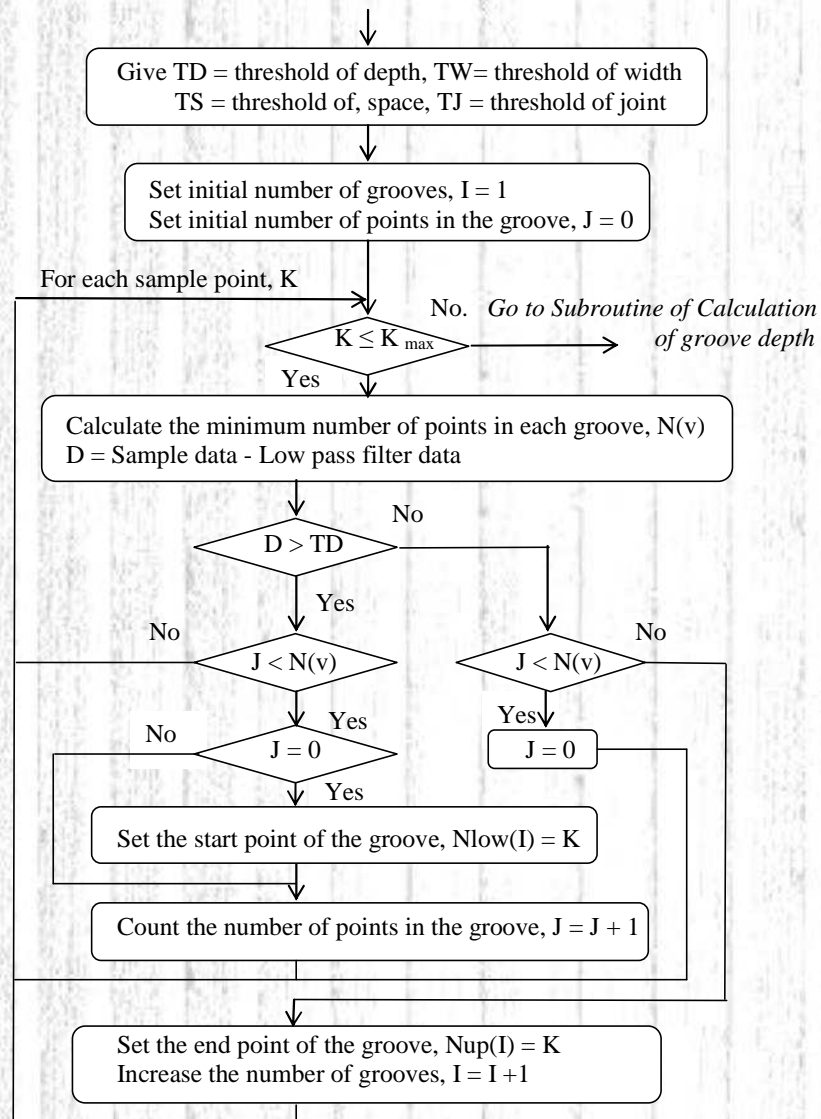
Groove Identification Procedure

1. The profile data is first high-pass filtered at 0.07 cycle/ft to remove the roughness components in the profile.

2. The high-pass filtered profile data is followed by low-pass filtering at 3.3 cycle/ft to provide a datum against which groove-like disturbances can be compared.

3. The low-pass filtered datum provides a moving average of the profile which lies between the top and the bottom of the grooves for comparison.

4. Groove-like disturbances of joints in concrete pavements are found and removed from the counted grooves.

5. The potential groove depth and width are double checked for assuring the groove depth and width within the defined limits.

6. The results of the groove depth and width are statistically analyzed, displayed, and printed out to the files.

Comparing with moving average of the profile

To find the start point and end point of each groove is performed on checking the difference between the sample value and the low-pass criteria.

Find the start point and end point of each groove

Flowchart:
- Give TD = threshold of depth, TW= threshold of width TS = threshold of, space, TJ = threshold of joint
- Set initial number of grooves, I = 1; Set initial number of points in the groove, J = 0
- For each sample point, K
- $K \leq K_{max}$ — No. *Go to Subroutine of Calculation of groove depth*
- Yes: Calculate the minimum number of points in each groove, N(v); D = Sample data - Low pass filter data
- D > TD — No / Yes
- J < N(v) — No / Yes; J < N(v) — No / Yes
- J = 0 (Yes); J = 0 (Yes)
- Set the start point of the groove, Nlow(I) = K
- Count the number of points in the groove, J = J + 1
- Set the end point of the groove, Nup(I) = K; Increase the number of grooves, I = I +1

1. The start point is localized at the difference between the sample data and filter data is greater than the given depth threshold.

2. calculate the minimum number of points in each groove, *N(v),* which depends on the vehicle speed.

3. If the number of satisfied difference between the sample and filter data is greater than the *N(v),* the potential groove is identified.

4. Then, the end point is found as the difference between the sample data and filter data less than the depth threshold.

Critical Frequency Depends on the Vehicle Speed

The vehicle speed usually changes at the start and end periods of test. If using low-pass filter to identify the grooves , the critical frequency can be adjusted to the vehicle speed on the specific time interval.
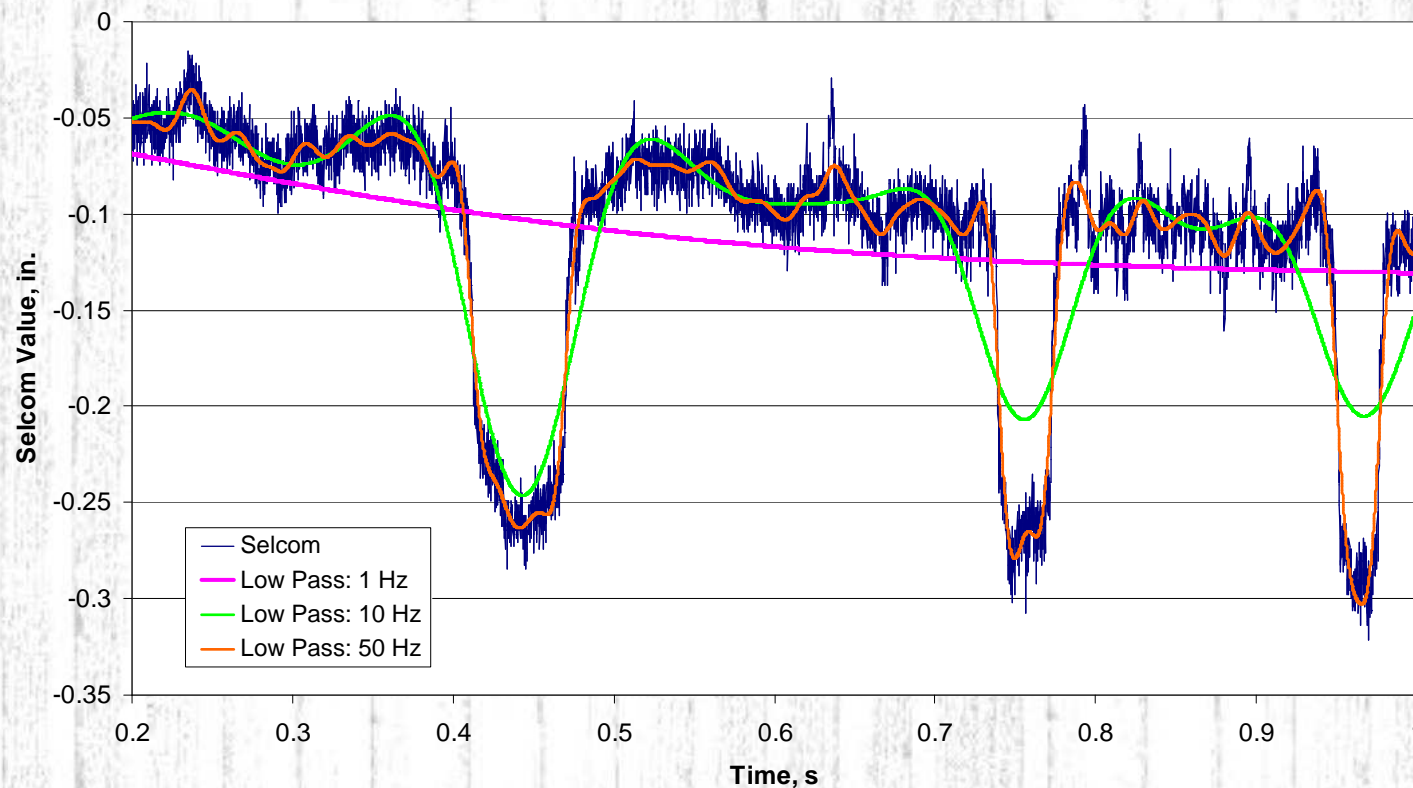
Remove the Joints from the Test Data

To determine the joints from a series of grooves is based on the two normally spaced grooves. It is obvious that the joint space is much greater than the normal groove space.
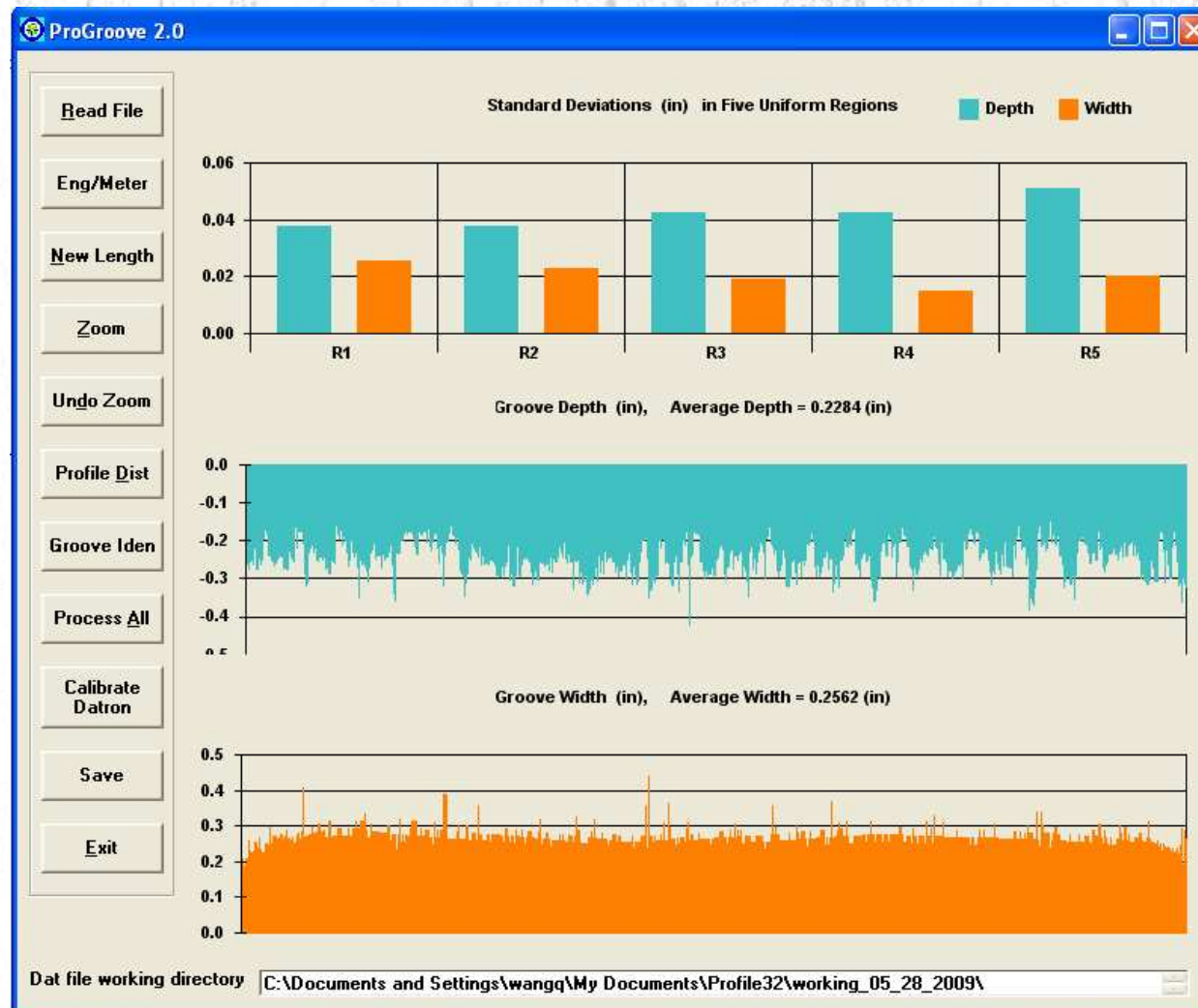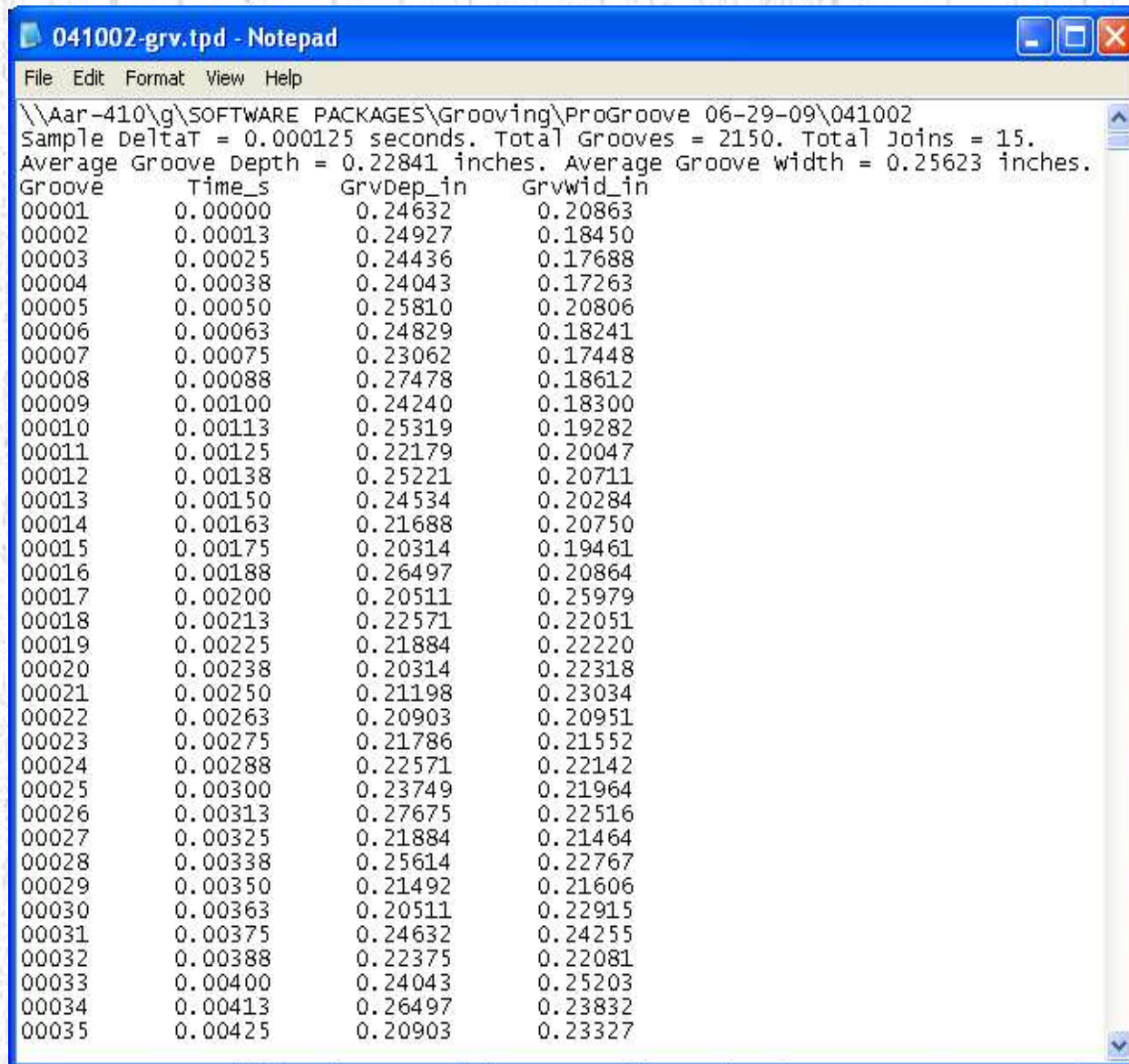
Distance Between Two Grooves
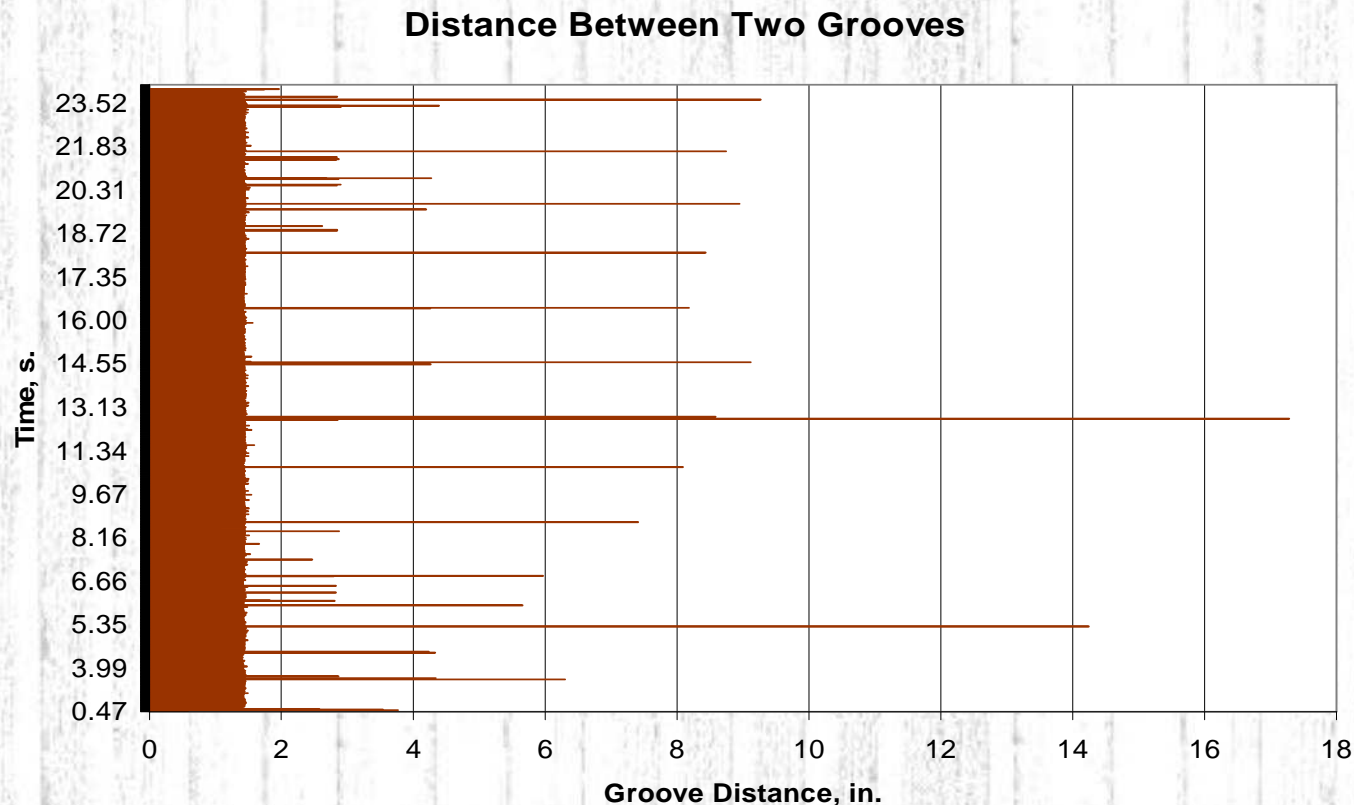
Remove the Joints from the Test Data

The potential groove depth and width are double checked for assuring the groove depth and width within a reasonable range.
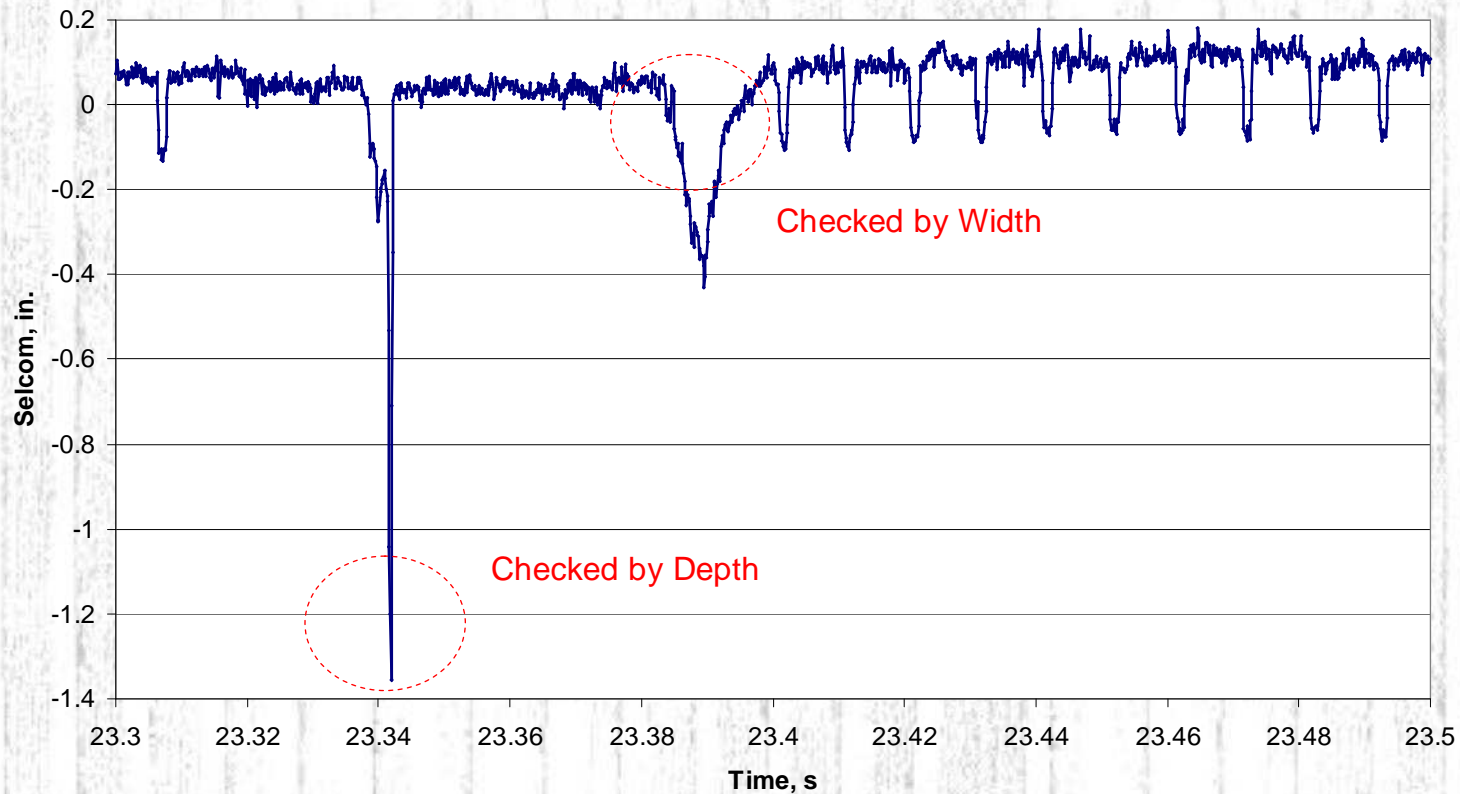
Depth, Width and Standard Deviations of the Grooves

# Storage Information of Groove Identification to a File

Verification to Manual Measurements

The groove data were tested at the Atlantic City Airport on October 22, 2008. Instrumental test and manual measurement were recorded for *ProGroove* analysis.

Verification to Manual Measurements

ProGroove and Manual Measurement at ACY in Slab 14

Standard Deviation = 0.02044
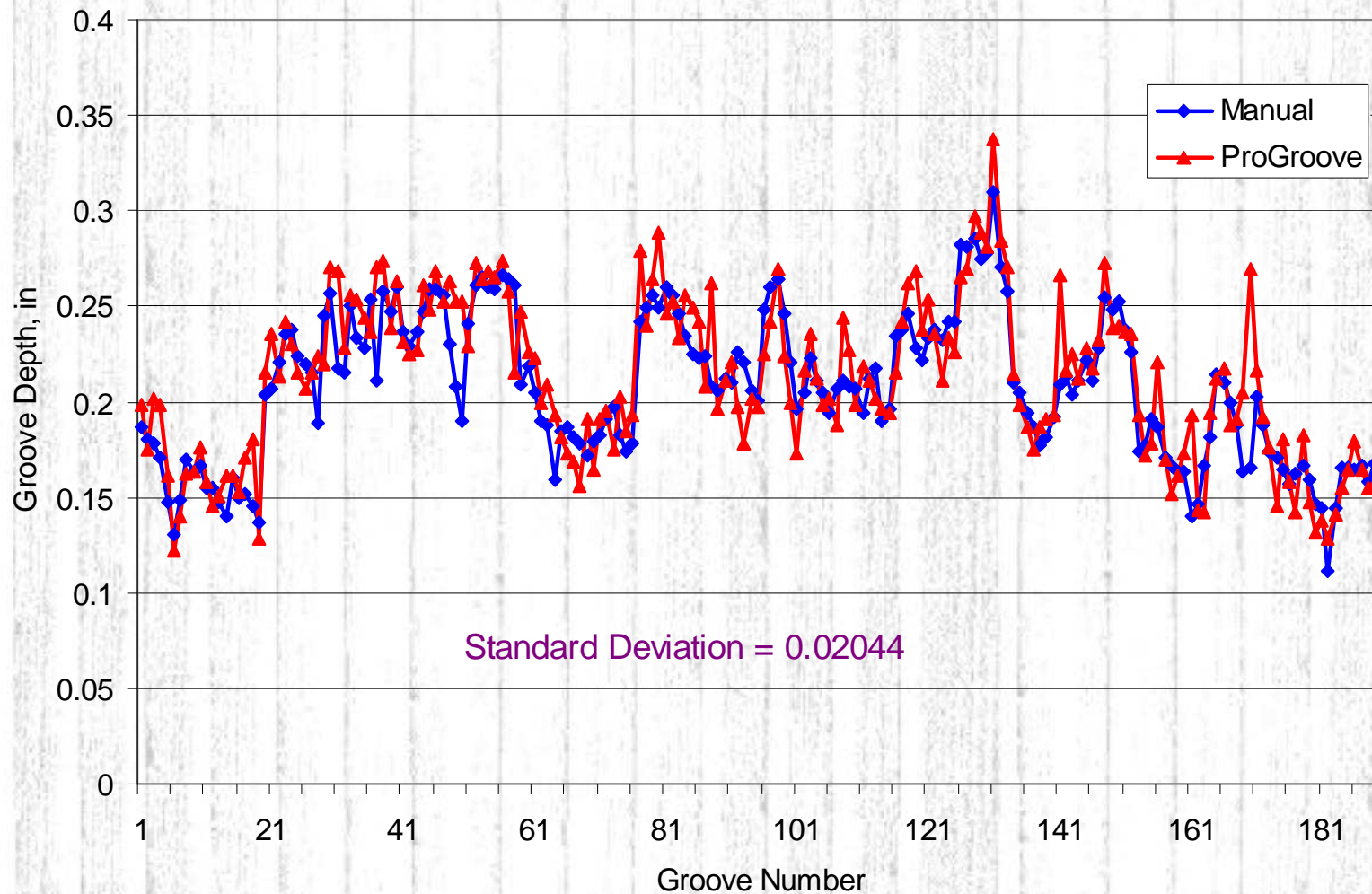
Conclusions

❑ *ProGroove* software can automatically identify the airport runway grooves by signal processing of the instrumental test data.

❑ *ProGroove* software provides the groove number, location, depth and width, as well as a series of statistical results for groove quality analysis.

❑ The comparison of analyzed data from *ProGroove* software with manual measurement shows good coincidence.

❑ The results of groove analysis can be used for verifying the initial construction of the groove quality or supplying the recommendations to the airport's maintenance program.

Thank You!